Large VAVs, Low Loads, and High Performance

The Problem

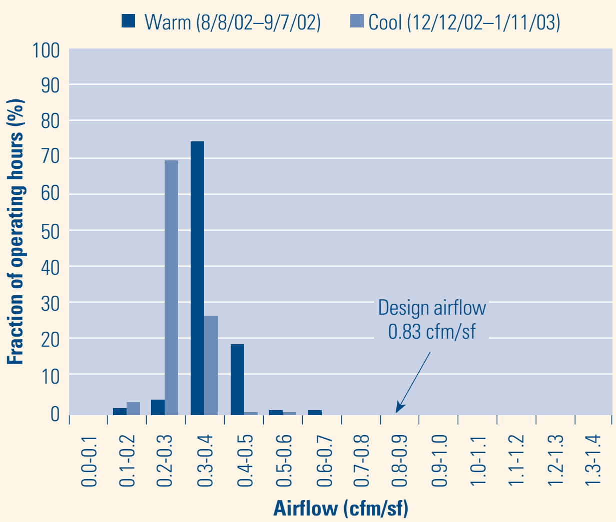
Many large commercial buildings use variable air volume (VAV) systems to deliver the proper amount of chilled air throughout a building. VAV systems can be very efficient at full load, but large buildings typically spend most of their time operating at part load (see **Figure 1**). At part load, VAV systems often operate far less efficiently than they could. That's because air distribution system components are typically not selected and controlled to work together in an integrated fashion.

The Solution

The *Advanced Variable Air Volume System Design Guide*, available from the California Energy Commission, provides best-practice recommendations for VAV air-side system design. The guide covers fans, air handlers, ducts, terminal units, diffusers, and controls, with an emphasis on getting the air distribution system components to work together in an integrated fashion. It is based on field experiences in designing and commissioning mechanical and control systems in commercial buildings, and it is informed by five field studies.

Figure 1: HVAC systems operate at part load much of the time

Measured airflow in this building shows that the HVAC system spends more than 70 percent of the time operating at less than one-half the design airflow—a result that is typical for office buildings.



Notes: cfm = cubic feet per minute; sf = square feet.

Features and Benefits

The guide features chapters on early design issues; zoning; VAV box selection; duct design; supply air temperature control; fans, coils, and filters; and outside-, return-, and exhaust-air control.

As part of an integrated design process, the guide recommends that the architect and structural engineer work together early in the process to design and locate shafts for low-pressure air paths. Then, the design team should work with the architect to evaluate glazing and shading alternatives to reduce loads, glare, and radiant discomfort while providing daylight, views, and architectural appeal. In addition, before starting the mechanical design for any space, the team should first consider options for reducing the loads on each space.

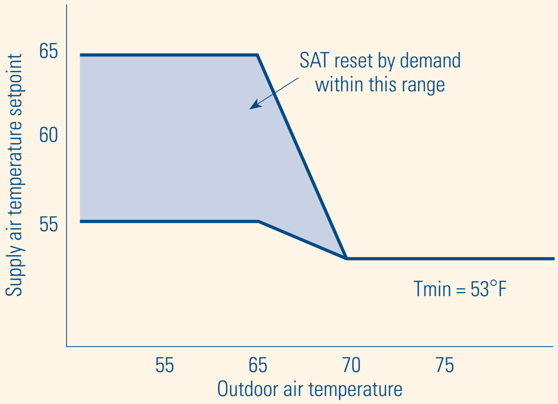
The heart of the guide is summarized in a list of 43 key recommendations for system design, including these:

- Use a "dual maximum" control logic, which allows for a very low minimum airflow rate during no- and low-load periods.
- Set the minimum airflow setpoint to the larger of the lowest controllable airflow setpoints allowed by the box and the minimum ventilation requirement—often as low as 0.15 cubic feet per minute per square foot (cfm/ft^2).
- For all except very noise-sensitive applications, select VAV boxes for a total (static plus velocity) pressure drop of 0.5 inches H_2O to optimize energy use over the course of a year.
- Use supply air temperature reset controls to avoid turning on the chiller whenever possible (see **Figure 2**, next page).
- Use demand-based static pressure setpoint reset to reduce fan energy up to 50 percent, reduce fan operation in surge conditions, reduce noise, and improve control stability.

Application of the design principles outlined in the guide can improve part-load performance of large VAV systems, thereby cutting HVAC system electricity use by 25 percent or more and cutting gas heating energy use by 41 percent compared to standard practice. In addition, building owners and developers can expect reduced maintenance costs and improved occupant comfort.

Figure 2: Recommended supply air temperature reset method

In this control sequence, the supply air setpoint is 53°F when the chiller is likely to be on (that is, when the outdoor air temperature is 70°F or above). However, when the outdoor air temperature is lower than 70°F, the setpoint rises according to a demand-based control algorithm, which uses the warmest supply air temperature that satisfies all of the cooling requirements of the zones. This keeps the chillers off as long as possible and lowers the amount of energy necessary for reheat.



Notes: F = Fahrenheit;
SAT = supply air temperature;
Tmin = minimum temperature.

Applications

The *Advanced Variable Air Volume System Design Guide* is written for HVAC designers and focuses on built-up VAV systems in multistory commercial office buildings with over 100,000 ft^2 of floor area. However, much of the information provided can also be applied to a wide range of system types, building types, and locations.

California Codes and Standards

Findings made in the course of developing the guide—regarding static pressure reset, sensor location, and fan power sizing—were used to modify the prescriptive requirements for space-conditioning systems in the California 2005 Building Energy Efficiency Standards (Title 24).

What's Next

A team from Taylor Engineering is currently making improvements to the guide with funding from several California utilities. The company is converting the guide to a web-based tool that will enable users to link to online modeling systems. The updated guide will be posted on the utilities' Energy Design Resources web site. Taylor Engineering and Architectural Energy Corp. (formerly Eley Associates) are also incorporating a new VAV simulation model, which was written in the course of developing the guide, into Energy Plus, the U.S. Department of Energy's building energy simulation software. The new routine more accurately represents fan system performance than the models in current simulation programs.

Collaborators

Taylor Engineering, Architectural Energy Corp., and the New Buildings Institute collaborated on this project.

For More Information

Reports documenting this project and providing more details may be downloaded from the web at www.energy.ca.gov/pier/final_project_reports/500-03-082.html.

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About PIER

This project was conducted by the California Energy Commission's Public Interest Energy Research (PIER) program. PIER supports public-interest energy research and development that helps improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

Arnold Schwarzenegger, *Governor*

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